Wind Potential and Grid Integration

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FY2005 DOE Wind Program R&D Implementation Meeting

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Major Issues

Important wind resource components for studies of wind power potential and utility grid integration are:

- Available windy land area and wind electric potential considering environmental and land use exclusions
- Seasonal and diurnal variability of the wind resource

Wind Potential Estimates

- Opportunity
  - New high-resolution wind maps and detailed land use data permit development of highly refined estimates (compared to previous estimates from1990s)
- Problem – Windy land area and wind potential difficult to quantify precisely
  - Requires complex GIS integration of environmental and land use data sets and exclusion methodology
  - Uncertainties of how to treat specific land use types and exclusion criteria
  - Data sets not consistent among states
- Challenge – Establishing a consistent methodology and data sets for widespread application

Wind Potential Estimates - Past Work

- First wind potential estimates made in early 1990s, considering environmental and land-use exclusions and based on the 1987 U.S. wind atlas.
- 1990s study was well-received and is the official program basis for wind potential estimates
- Recent availability of updated state wind maps and land-use data sets created demand for updated estimates of wind potential.
- 1990s approach modified and estimates updated for specific applications (only for DOE WPA, EIA, NREL use)
- Updated methodology not final and undergoing review

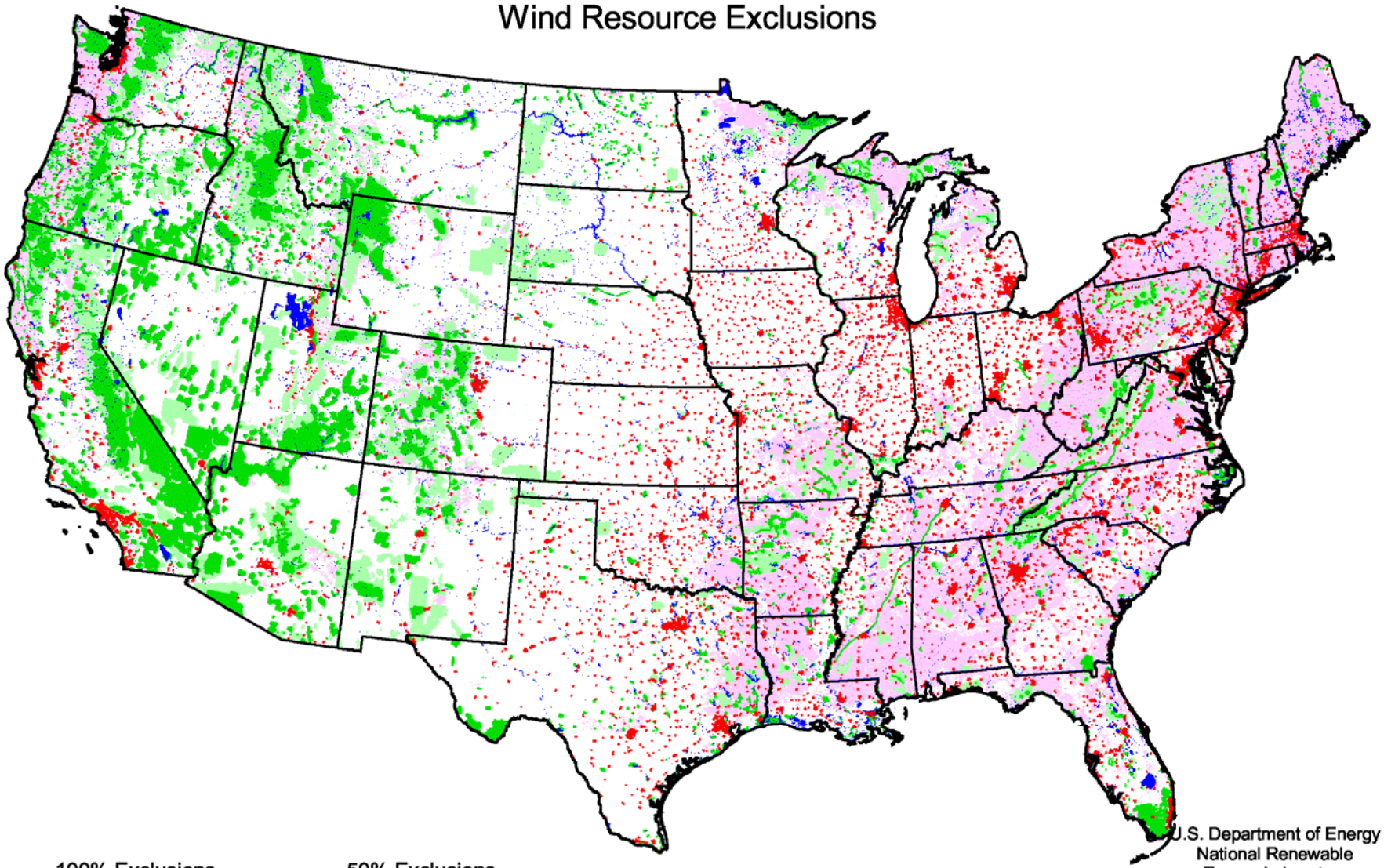
Wind Potential – Recent Activities

- Documentation of methodology and incorporation of new data sets
  - Comparison of methodology and estimates to 1990s studies
  - Development of tracking form for model data inputs
- Updated estimates for energy modeling studies by DOE, NREL, and other agencies:
  - DOE/EIA NEMS (National Energy Modeling System)
  - DOE/NREL WinDS (Wind Deployment System)
  - Northeast States RGGI (Regional Greenhouse Gas Initiative)
- Updated estimates for Wind Powering America
  - For specific states only (trying to avoid comparison or ranking of states).
  - For Native American lands, electric transmission corridors, and other specific areas

Quantifying Available Windy Lands
(Draft - Under Review)

- Environmental Exclusions
  - 100% Exclusions
    - National Park Service, Fish and Wildlife Service, State and private environmental lands (where available in GIS)
    - Wildlife, Wilderness, and Recreation Areas on federal land
  - 50% Exclusion of remaining Forest Service and DOD lands
- Land Use Exclusions
  - 100% Exclusions
    - Urban areas and airports
    - Wetlands and water bodies
  - 50% Exclusions of non ridge crest forest
- Other
  - Slope greater than 20% excluded 100%
  - 3 km buffer around airports and the 100% exclusion areas, except around water bodies
  - Minimum density of windy land

Wind Resource Exclusions



100% Exclusions

- Urban or Airports
- Water
- Sensitive Environmental Lands

Includes 3 kilometer buffer around urban and environmental lands.

50% Exclusions

- Other Forest Service or Dept. of Defense Lands
- Non-ridgecrest Forest

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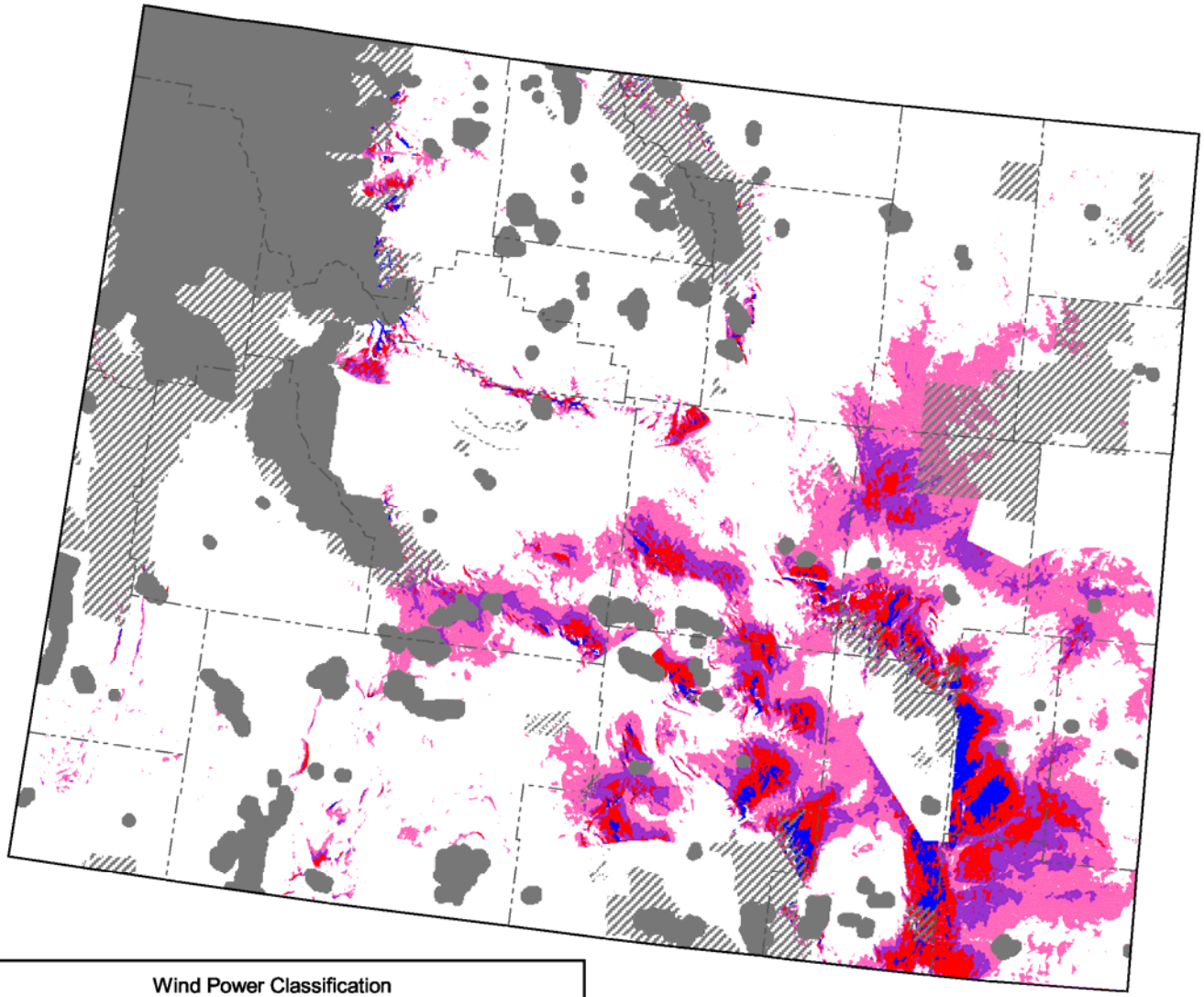
Wyoming

Available Windy Land Within 20 Miles of Transmission 69 - 345 kV



The wind power resource data for this map was produced by TrueWind Solutions using the Mesomap system and historical weather data. It has been validated with available surface data by the National Renewable Energy Laboratory and wind energy meteorological consultants.

100% Excluded Areas
50% Excluded Areas

Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m ^{2}	Wind Speed [a] at 50 m m/s	Wind Speed [a] at 50 m mph
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	> 800	> 8.8	> 19.7

[a] Wind speeds are approximate and based on a Weibull k value of 2.0

40 0 40 80 120 160 Kilometers

25 0 25 50 75 100 Miles

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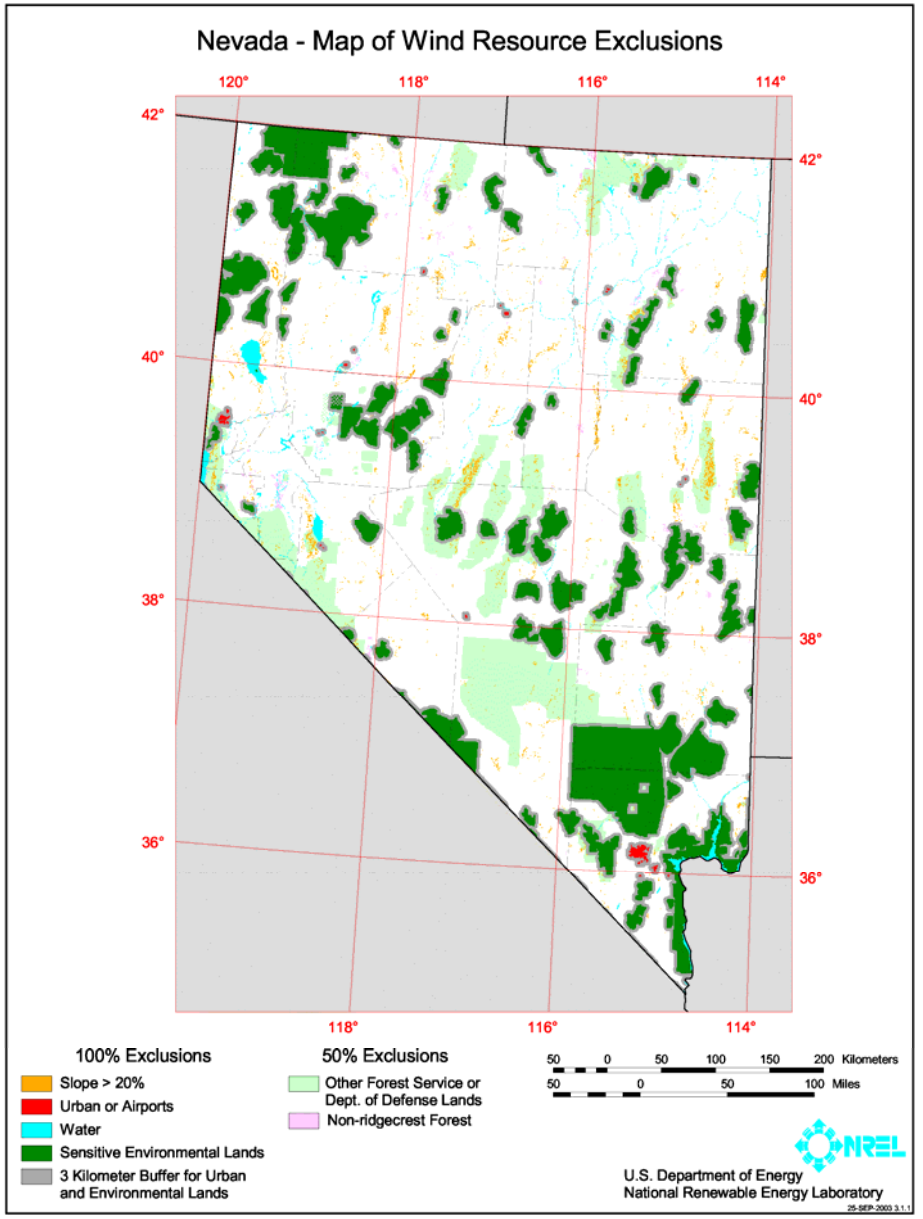
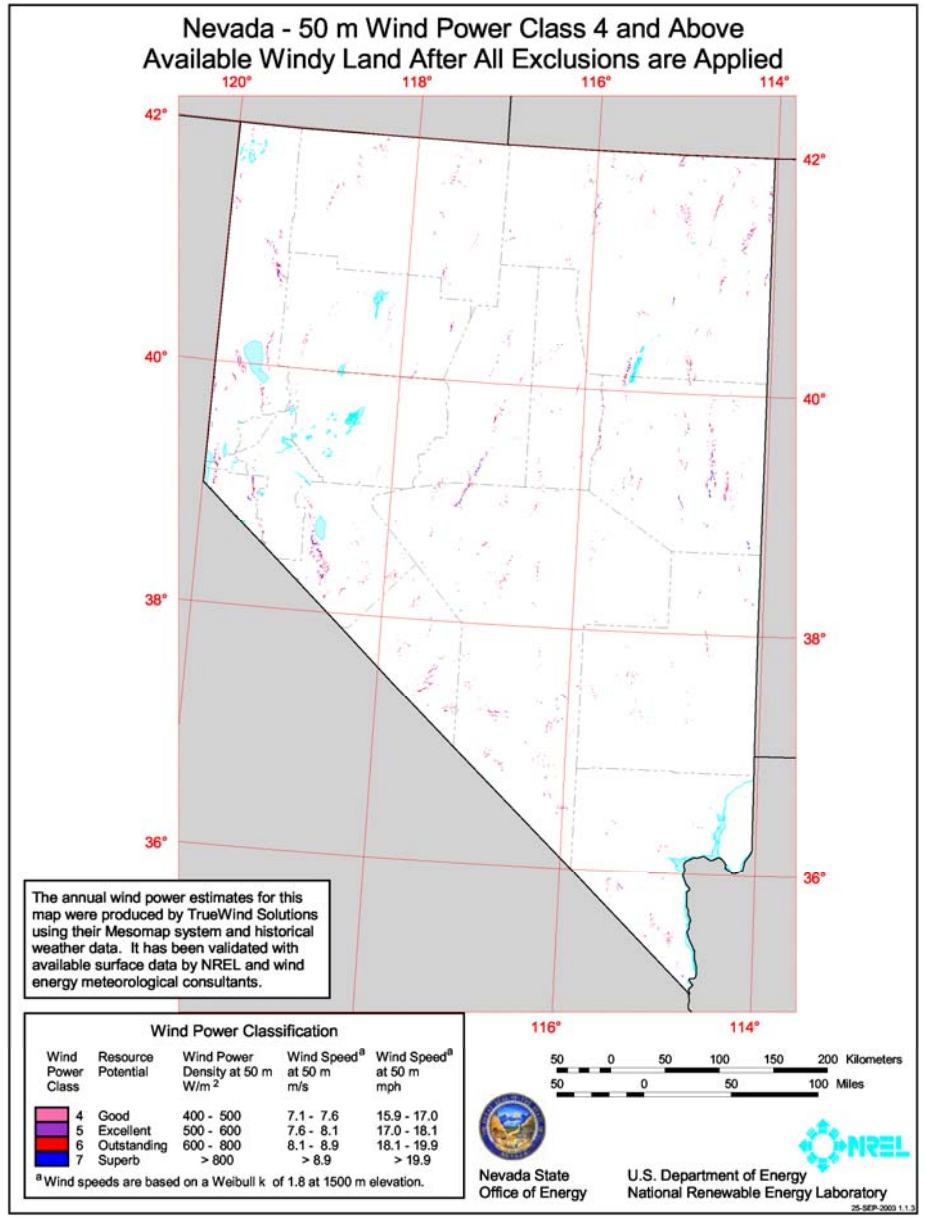
1,326 km^2 (6,630 MW) Class 4+ After Exclusions

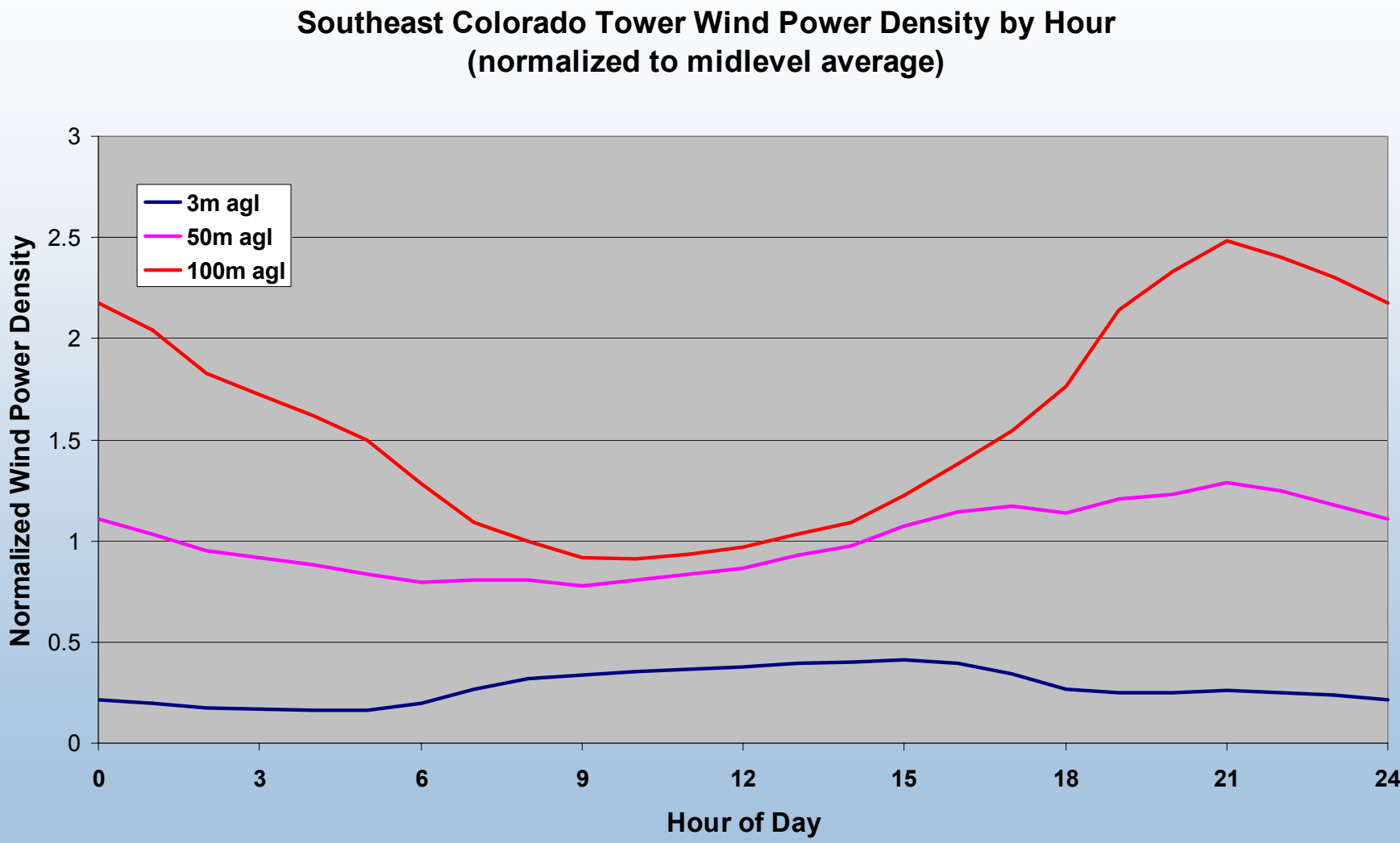




Seasonal and Diurnal Wind Profiles

- Issue – Critical need for power profiles that directly address
  - geographic diversity in transmission grid
  - generation planning
- Problem – Lack of measurement data from hub-height levels of new turbines (70-100m) to characterize seasonal and diurnal wind characteristics
  - Diurnal profile structure changes dramatically with height in many regions of U.S.
  - Extrapolations from low-level data create large uncertainties
  - Data inadequate to validate model-derived estimates except for a few sites in specific areas
  - Optimum to have time-synchronized data (same year) but data often from different years
- Challenge – Developing a reasonable approach given the data constraints

Example of Dramatic Change of Diurnal Wind Profile with Height above Ground



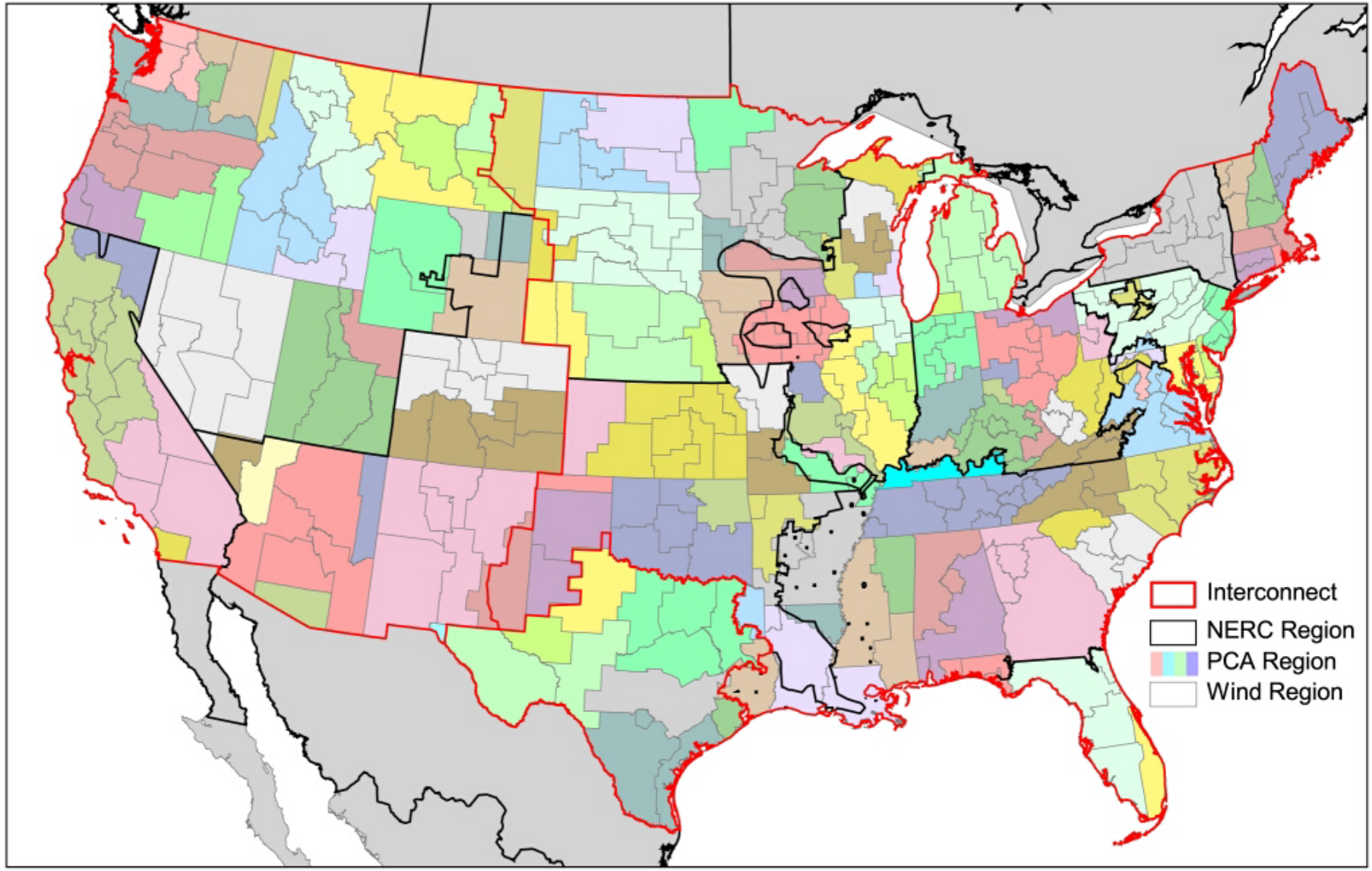
Seasonal and Diurnal Profiles - Past Work

- Analysis of historical wind measurement data, including seasonal and diurnal profiles, for examining wind resource climates
  - Public data largely from levels near ground and very limited at heights above 50 m
  - Analysis of wind resource climates important component of NREL's state mapping work
- Input data for Rocky Mountain Area Transmission Study
  - Analyzed available wind data for specific areas in 5 states (CO, UT, WY, ID, MT)
  - Developed estimates of seasonal and diurnal profiles and adjusted time-series data for 80-m height
  - Large uncertainties in estimates due lack of data from heights above 50 m and complex wind climates
- Input data for WinDS model
  - Prototype test using wind map estimates and available measurements for a specific area

FY 05 Activities

- Budget - $180K in-house
- Review/refine wind potential methodology
  - Identify land-use experts that will assist in quantification of exclusions
  - Form internal working group to address exclusions and wind potential methodology
  - Conduct survey with land-use experts and appropriate agencies
- Provide technical support for regional transmission integration studies
  - Likely study areas: 1)Arizona and New Mexico, 2) Washington and Oregon, 3)Kansas and Oklahoma
  - Develop seasonal and diurnal profiles and time-series data sets using combination of available measurement data and model output data from maps
- Provide input for WinDS energy model simulations
  - Develop approach on how to supply nationwide seasonal and diurnal profiles
  - Deliver interim WinDS estimation of hourly power profiles

WinDS Energy Modeling Regions



Timeframe?

- Wind Potential Estimates
  - Revision and acceptance of final procedures for estimating available windy land and wind potential
  - Release of updated state estimates (for only states with NREL validated maps?)
- Wind Data for Transmission Integration and Energy Models
  - Virtual tower comparisons to measurements
    - Establish project to generate and validate virtual model output data
    - Comparisons to measurement data – tall towers and remote sensing data
  - Develop improved methods and data sets for seasonal and diurnal profiles at turbine hub-heights